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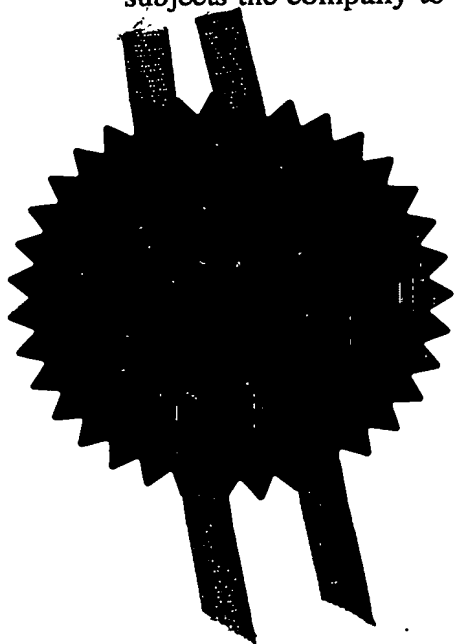
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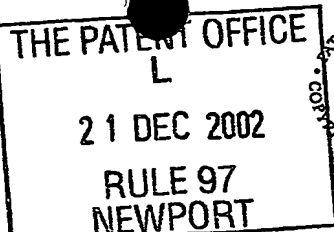


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24DEC02 5702982-1 D00333
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1. Your reference

W071859PGB

21 DEC 2002

2. Patent application number

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0229871.9

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Foseco International Limited
Coleshill Road, Fazeley,
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00019987005

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

England

4. Title of the invention

ROTARY DEVICE FOR TREATING MOLTEN METAL

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

MARKS & CLERK
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Birmingham
B1 1TT, England

Patents ADP number (if you know it)

18002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number
(if you know it)

Date of filing
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Number of earlier application

Date of filing
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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

YES

- a) any applicant named in part 3 is not an inventor, or
 - b) there is an inventor who is not named as an applicant, or
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Patents Form 1/77

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Description	10
Claim(s)	4 DM1
Abstract	1
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Priority documents

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Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

1 ✓

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Any other documents (please specify)

11. I/We request the grant of a patent on the basis of this application.

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Date

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12. Name and daytime telephone number of person to contact in the United Kingdom

David I Ward 0121 643 5881

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[DUPLICATE]

- 1 -

ROTARY DEVICE FOR TREATING MOLTEN METAL

The present invention relates to a rotary device for treating a molten metal.

It is well known that the presence of dissolved gas in molten metal can introduce defects in the solidified product. For example, defects are introduced in castings and wrought products manufactured from aluminium or its alloys due to porosity arising from the presence of hydrogen gas. For example, hydrogen gas diffusing to voids and discontinuities (e.g. oxide inclusions) can result in blister formation during the production of aluminium alloy plate, sheet and strip. Other defects such as porosity in castings may also be associated with the presence of hydrogen gas.

It is common practice to treat molten aluminium and its alloys to remove hydrogen and solid impurities by flushing with a gas such as chlorine, argon, nitrogen or a mixture of these gases, the process commonly being referred to as "degassing". One way of performing the degassing is to use a hollow shaft to which a rotor is attached. In use the shaft and rotor are rotated and gas is passed down the shaft and dispersed into the molten metal via the rotor. An example of such an assembly is described in EP 0332292 (the entirety of which disclosure is included herein by reference) and shown in Figure 1. The rotor 2 comprises a number of compartments C each of which has an inlet 9 and an outlet 10, adjacent compartments being separated by vanes 11. The rotor is characterised by having an open chamber M in its base and by having the outlets larger than the inlets. The rotor is connected to a hollow shaft via a tubular connection piece.

It is an object of the present invention to provide an improved rotary device which preferably offers one or more of the following advantages over the known devices:-

- (i) higher durability and therefore longer life,
- (ii) more rapid degassing, and
- (ii) more efficient removal of solid impurities such as oxide inclusions.

According to the present invention there is provided a rotary device for dispersing a gas in a molten metal, said device comprising a hollow shaft at one end of which is a rotor, said rotor having a roof and a base, said roof and base being spaced apart and connected by a plurality of vanes, a compartment being defined between each adjacent pair of vanes and the roof and the base, each compartment having an inlet and first and second outlets, a flow path being defined through the shaft into the inlets of the compartments and out of the first and second outlets, wherein each first outlet is disposed radially outwardly of the respective inlet and arranged to disperse gas laterally of the rotor in use, and wherein each second outlet is disposed in the roof of the rotor and arranged to disperse gas upwardly from the rotor in use.

Surprisingly, the inventors have found that the combination of laterally directed and upwardly directed outlets allows smaller and more numerous bubbles of gas to be created which results in significantly more efficient degassing and cleaning compared to the device of EP 0332292 such that the rotation speed can be reduced while maintaining the same efficiency of degassing/cleaning, thereby extending the life of the shaft and rotor, or degassing/cleaning can be achieved more efficiently at the same rotor speed, providing the opportunity to reduce treatment time.

Preferably, each second outlet is a cut-out extending inwardly from the outer periphery of the roof. Conveniently, the cut-outs are part-circular or semi-circular and are preferably arranged symmetrically around the rotor. It will of course be appreciated that the cut-outs can be of any shape and that one or more of the second outlets could alternatively be constituted by a bore (of any shape) through the roof into one of the compartments.

In a preferred embodiment, the rotor has four compartments (defined by four vanes) with eight second outlets in the form of semi-circular cut-outs arranged symmetrically around the rotor (i.e. two per compartment). However, the number of outlets may be increased (e.g. to 12 or 16) for larger rotors and reduced for smaller rotors.

Preferably, the rotor is provided with a chamber in which mixing of molten metal and gas can take place. Preferably, the chamber is located radially inwardly of the inlets, preferably has an opening in the base of the rotor and is in the flowpath between the shaft and the inlets, such that in use when the device rotates, molten metal is drawn into the chamber through the base of the rotor where it is mixed with gas passing into the chamber from the shaft, the metal/gas dispersion then being pumped into the compartments through the inlets before being discharged from the rotor through the first and second outlets.

Preferably, the first outlets have a greater cross-sectional area than the inlets.

Preferably the rotor is circular in transverse cross section and is most preferably attached to the shaft at its centre, so as to reduce drag during rotation.

Preferably, the shaft and rotor are formed separately, the two being attached together by releasable fixing means. The shaft may be connected directly to the rotor (e.g. by providing mating screw threads on each of the shaft and rotor), or indirectly, e.g. via a threaded tubular connection piece.

The rotor is conveniently formed from a solid block of material (preferably graphite), the compartments being conveniently formed by a milling operation.

For the avoidance of doubt, it should be made clear that the invention resides also in the rotor per se.

The present invention further resides in a method of treating molten metal comprising the steps of:-

- (i) immersing the rotor and part of the shaft of the device of the present invention in the molten metal to be treated,
- (ii) rotating the shaft, and
- (iii) passing gas and optionally one or more treatment substances down the shaft and into the molten metal via the rotor, whereby to degas the metal.

The nature of the molten metal is not restricted. However, preferred metals for the treatment include aluminium and all its alloys (including low silicon alloys (4-6% Si) e.g. BS alloy LM4 (Al-Si5Cu3); medium silicon alloys (7.5-

9.5% Si) e.g. BS alloy LM25 (Al-Si7Mg); eutectic alloys (10-13% Si) e.g. BS alloy LM6 (Al-Si12); hypereutectic alloys (> 16% Si) e.g. BS alloy LM30 (Al-Si17Cu4Mg); aluminium magnesium alloys e.g. BS alloy LM5 (Al-Mg5Si1; Al-Mg6), magnesium and its alloys (e.g. BS alloy AZ91 (8.0-9.5% Al) and BS alloy AZ81 (7.5-9.0% Al)) and copper and its alloys (including high conductivity coppers, brasses, tin bronzes, phosphor bronzes, lead bronzes, gunmetals, aluminium bronzes and copper-nickels).

Preferably, the gas is an inert gas (such as argon or nitrogen) and is more preferably dry. Gases not traditionally regarded as being inert but having no deleterious effect on the metal may also be used such as chlorine, or a chlorinated hydrocarbon. The gas may be a mixture of two or more of the foregoing gases. From a balance between cost and inertness of the gas, dry nitrogen is preferred. The method is particularly useful for the removal of hydrogen gas from molten aluminium.

It will be understood that for any given rotor, efficiency of degassing will be determined by the speed of rotation, the gas flow rate and treatment time.

As well as degassing, the treatment may also be combined with the injection of fluxes into the melt along with the inert purge gas. The treatment is then a combined degassing/grain refinement and/or modification and/or cleaning/drossing treatment, in which case the optional treatment substance may be granulated cleaning/drossing, grain refining, modification species or a combination of these (usually referred to as "flux" or "fluxes"). Such fluxes may be titanium and/or boron salts (e.g. AlTiB alloy) for grain refining, and sodium salts or strontium (usually as 5-10% master alloy) for

modification of aluminium-silicon alloys. Such processes are per se well known to the skilled foundryman.

The required size of the rotor, speed of rotation, gas flow rate and (optional) flux quantity will all be determined by the particular treatment being undertaken, taking into account the mass of metal being treated, the optimum treatment time and whether the process is a continuous or a batch process.

An embodiment of the invention will now be described by way of example only, with reference to the accompanying drawings in which:-

Figure 1 is a vertical section through a prior art rotor described in EP0332292,

Figures 2a and 2b are respectively a perspective and a side view of a rotary device in accordance with the present invention,

Figure 3 is a top plan view of the rotor of Figures 2a and 2b, and

Figures 4 to 6 are graphs illustrating reduction in gas content of AlSi10Mg before and after degassing with nitrogen using a rotor according to the present invention and a comparative rotor.

Referring to Figures 2 and 3, a rotary device for dispersing gas and/or other treatment substances in molten metal is shown. The device comprises a shaft 20 having a bore 20a therethrough, a rotor 22 and a tubular connection piece 23.

The rotor 22 is made from graphite and is of unitary construction. The rotor 22 is generally disc-shaped and comprises an annular upper part (roof 24) and spaced therefrom an annular lower part (base 26). A threaded throughbore

28 is provided centrally in the roof 24 of the rotor 22 and serves in use as an attachment point for the tubular connection piece 23 which is correspondingly externally screw-threaded. An open chamber 30 is provided centrally in the base 26 of the rotor 22. The chamber 30 extends upwardly to the roof 24 of the rotor 22 and is continuous with the throughbore 28 in the roof 24, the throughbore 28 and chamber 30 thereby defining a continuous passage vertically through the rotor 22. The chamber 30 extends radially outwardly further than the throughbore 28. The roof 24 and base 26 are connected by four vanes 32 which are disposed between the roof 24 and the base 26 and which extend outwardly from the periphery of the chamber 30 to the periphery 22a of the rotor 22. A compartment 34 is defined between each pair of adjacent vanes 32, the chamber 30 and the roof 24 and the base 26. Each compartment 34 has an inlet aperture 36 from the chamber 30 and a first outlet on the periphery 22a of the rotor 22 in the form of an elongated slot 38. The outlet slot 38 has a greater cross-sectional area than the inlet aperture 36.

As can be seen more readily in Figure 3, the peripheral edge 22a of the roof 24 of the rotor 22 is provided with a plurality (eight in this embodiment) of part-circular cut-outs 40. Each cut-out 40 serves as a second outlet for its respective compartment 34 (in this case two cut-outs 40 are provided per compartment 34).

An appropriately internally screw-threaded region 20b is provided at one end of the shaft 20 for securely mounting the shaft 20 onto the connection piece 23. The opposite end of the shaft 20 is connected to the lower end of a hollow drive shaft (not shown) whose upper end is connected to drive means

(in this case an electric motor, not shown) and the bore 20a of the shaft 20 is connected through the hollow drive shaft to a source of gas (not shown).

From the description above, it will be clear that a continuous flow path exists from the source of gas, through the bore 20a of the shaft 20 and the connection piece 23, through the roof 24 of the rotor 22 into the chamber 30, through the inlet apertures 36 into the compartments 34 and out of the rotor 22 through the first and second outlets 38,40.

In use, the rotor and shaft assembly is immersed in the molten metal to be degassed (in for example a refractory lined ladle or other vessel) and rotated at the desired speed by activation of the electric motor. The source of gas is opened and adjusted to the desired flow rate and degassing carried out for a predetermined duration.

During degassing, gas passes down the shaft 20 into the rotor chamber 30, where it is mixed with molten metal which is drawn upwardly into the chamber 30. The gas/metal dispersion flows into the compartments 34 via the inlets 36 and exits the rotor 22 laterally through the first outlets 38 and upwardly through the second outlets 40.

Examples 1 to 3

A rotor as described above having a diameter of 190 mm was used to degas 200 Kg of AlSi10Mg alloy held at 720 °C. The gas used was dry nitrogen at a flow rate of 15 L/min. The speed of rotation was 450 rpm and degassing was carried out over 5 minutes (Example 1). The effectiveness of the rotor

was assessed by determination of the Density Index (DI) of the metal before and after treatment. DI is calculated using the formula

$$DI = \frac{Datm - D80mbar}{Datm} \times 100$$

where Datm is the density of a sample of metal which has been allowed to solidify under atmospheric pressure and D80mbar is the density of a sample which has been allowed to solidify under a vacuum of 80mbar. The higher the DI of a sample, the greater the hydrogen gas content of the metal.

Examples 2 and 3 were performed as for Example 1, except that the rotation speed used was 350 rpm (Example 2; treatment time 5 minutes, 2 runs, Example 3; treatment time 3 minutes, 2 runs).

Comparative Examples 1 to 3

For comparison, degassing was carried out under identical conditions to the corresponding Example using a rotor identical to that of Example 1, except that the roof of the rotor was not provided with any cut-outs.

RESULTS

The results in terms of density index (DI) reduction are tabulated below and represented graphically in Figures 3 to 5 (Examples/Comparative Examples 1 to 3). Although it will be appreciated that no two batches of melt will have exactly the same starting DI, it is readily apparent that the rotor of the present invention offers a significant improvement over a comparable rotor having the cut-outs omitted. For example, from Table 2 and Figure 3, it can be seen that the DI of Example 2 (both runs) is half that of comparative example 2 after treatment, even when the starting DI is higher (run 2).

Table 1: DI (%) (degassing at 450 rpm, 15 L/min for 5 mins)

	Example 1	Comparative example 1
Before	8.43	10.15
After	0.38	0.76

Table 2: DI (%) (degassing at 350 rpm, 15 L/min for 5 mins)

	Example 2		comparative example 2
	run 1	run 2	
Before	4.58	6.92	5.34
After	0.38	0.38	0.76

Table 3: DI (%) (degassing at 350 rpm, 15 L/min for 3 mins)

	Example 3		comparative example 3	
	run 1	run 2	run 1	run 2
Before	6.08	2.66	4.98	7.66
After	0	0.38	1.15	1.89

When the degassing time is reduced the efficiency of the comparative rotor deteriorates (comparative example 3), whereas the rotor of the present invention maintains the high reduction in DI (Example 3).

CLAIMS

1. A rotary device for dispersing a gas in a molten metal, said device comprising a hollow shaft at one end of which is a rotor, said rotor having a roof and a base, said roof and base being spaced apart and connected by a plurality of vanes, a compartment being defined between each adjacent pair of vanes and the roof and the base, each compartment having an inlet and first and second outlets, a flow path being defined through the shaft into the inlets of the compartments and out of the first and second outlets, wherein each first outlet is disposed radially outwardly of the respective inlet and arranged to disperse gas laterally of the rotor in use, and wherein each second outlet is disposed in the roof of the rotor and arranged to disperse gas upwardly from the rotor in use.
2. A device as claimed in claim 1, wherein each second outlet is a cut-out extending inwardly from the outer periphery of the roof.
3. A device as claimed in claim 2, wherein the cut-outs are part-circular or semi-circular and are preferably arranged symmetrically around the rotor.
4. A device as claimed in any preceding claim, wherein the rotor has four compartments (defined by four vanes) with eight second outlets in the form of semi-circular cut-outs arranged symmetrically around the rotor.
5. A device as claimed in any preceding claim, wherein the rotor is provided with a chamber in which mixing of molten metal and gas can take place.

6. A device as claimed in claim 6, wherein the chamber is located radially inwardly of the inlets and has an opening in the base of the rotor, such that in use when the device rotates, molten metal is drawn into the chamber through the base of the rotor where it is mixed with gas passing into the chamber from the shaft, the metal/gas dispersion then being pumped into the compartments through the inlets before being discharged from the rotor through the first and second outlets.
7. A device as claimed in any preceding claim, wherein the first outlets have a greater cross-sectional area than the inlets.
8. A device as claimed in any preceding claim wherein the rotor is circular in transverse cross section and is most preferably attached to the shaft at its centre.
9. A device as claimed in any preceding claim, wherein the shaft and rotor are formed separately, the two being attached together by releasable fixing means.
10. A device as claimed in any preceding claim wherein the rotor is formed from a solid block of material, preferably graphite.
11. A method of treating molten metal comprising the steps of:-
 - (i) immersing the rotor and part of the shaft of the device of any one of claims 1 to 10 in the molten metal to be treated,
 - (ii) rotating the shaft, and

(iii) passing gas and optionally one or more treatment substances down the shaft and into the molten metal via the rotor, whereby to degas the metal.

12. The method as claimed in claim 11, wherein the metal to be treated is selected from aluminium, magnesium, copper and alloys thereof.

13. The method as claimed in claim 11 or 12, wherein the gas used in step (iii) is selected from one or more of chlorine, a chlorinated hydrocarbon, nitrogen and argon.

14. The method as claimed in claim 13, wherein the gas used in step (iii) is dry nitrogen

15. The method as claimed in any one of claims 11 to 14, wherein the treatment comprises a grain refinement and/or modification and/or cleaning treatment and the optional treatment substance of step (iii) is a granulated cleaning/drossing, grain refining and/or modification species.

16. The method as claimed in claim 15, wherein the optional treatment substance is selected from one or more of titanium salts and/or boron salts, sodium salts and strontium master alloy.

17. A rotor for use in the rotary device of any one of claims 1 to 10, said rotor comprising a roof and a base, said roof and base being spaced apart and connected by a plurality of vanes, a compartment being defined between each adjacent pair of vanes and the roof and the base, each compartment having a gas inlet and first and second gas outlets, wherein each first outlet is disposed

- 14 -

radially outwardly of the respective inlet and arranged to disperse gas laterally of the rotor in use, and wherein each second outlet is disposed in the roof of the rotor and arranged to disperse gas upwardly from the rotor in use.

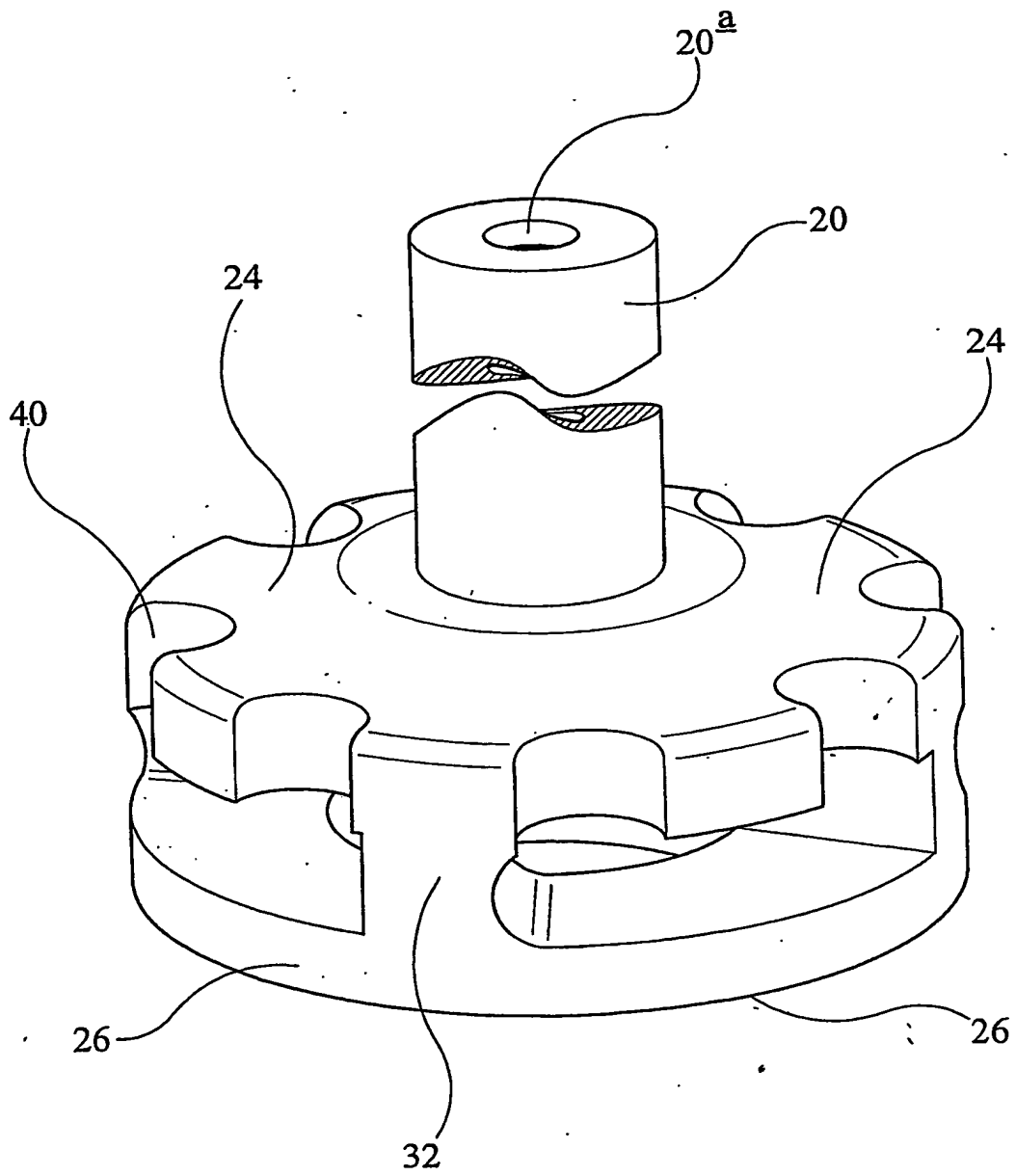
ABSTRACT

ROTARY DEVICE FOR TREATING MOLTEN METAL

The invention relates to a rotary device for dispersing a gas in a molten metal. The device comprises a hollow shaft (20) at one end of which is attached a rotor (22). The rotor (22) has a roof (24) and a base (26) which are spaced apart and connected by a plurality of vanes (32). A compartment (34) is defined between each adjacent pair of vanes (32) and the roof (24) and the base (26); and each compartment (34) has an inlet (36) and first and second outlets (38,40). A flow path is defined through the shaft (20) into the inlets (36) of the compartments (34) and out of the first and second outlets (38,40). Each first outlet (38) is disposed radially outwardly of the respective inlet (36) and arranged to disperse gas laterally of the rotor (22) in use, and each second outlet (40) is disposed in the roof (24) of the rotor (22) and arranged to disperse gas upwardly from the rotor (22) in use. (Figures 2 and 3)



FIG 2a



3 / 5

FIG 2b

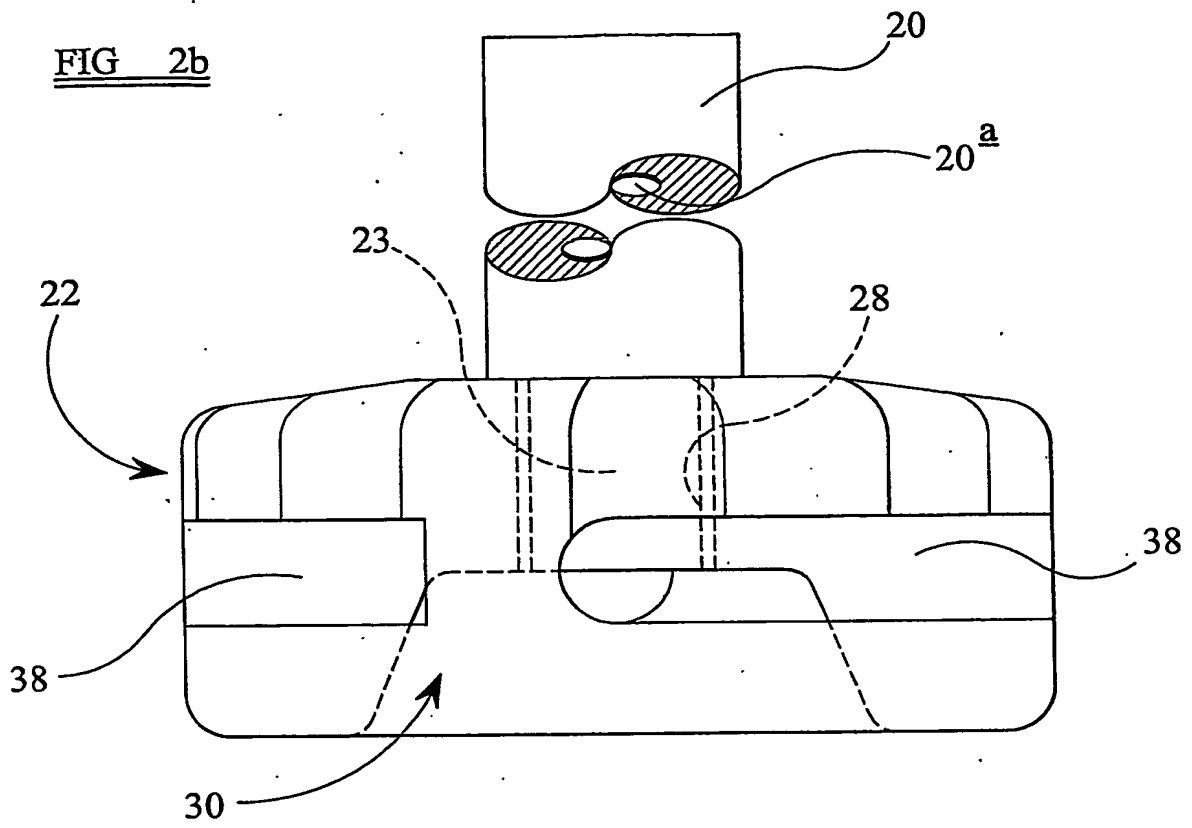
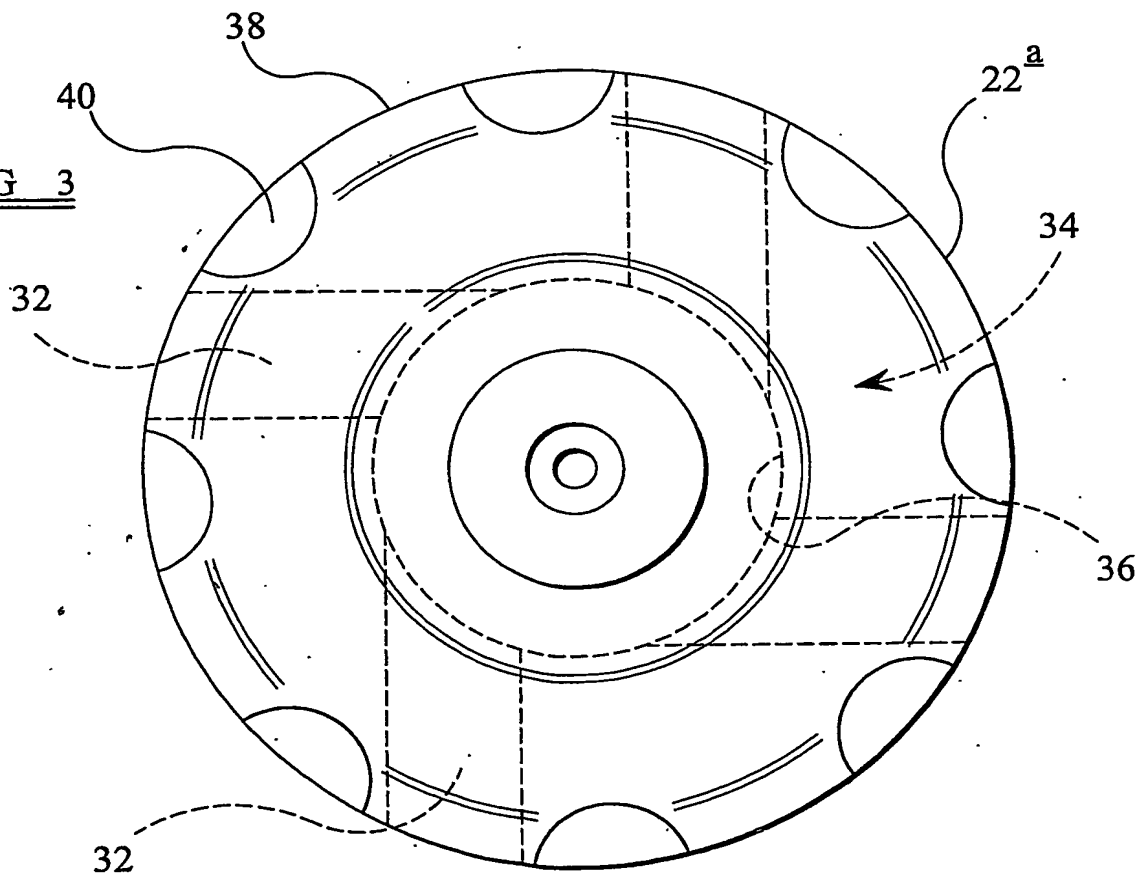


FIG 3



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Figure 4

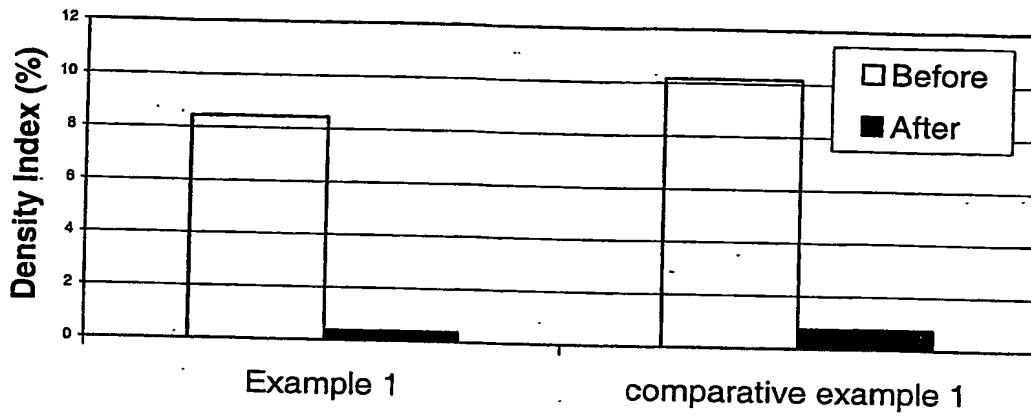
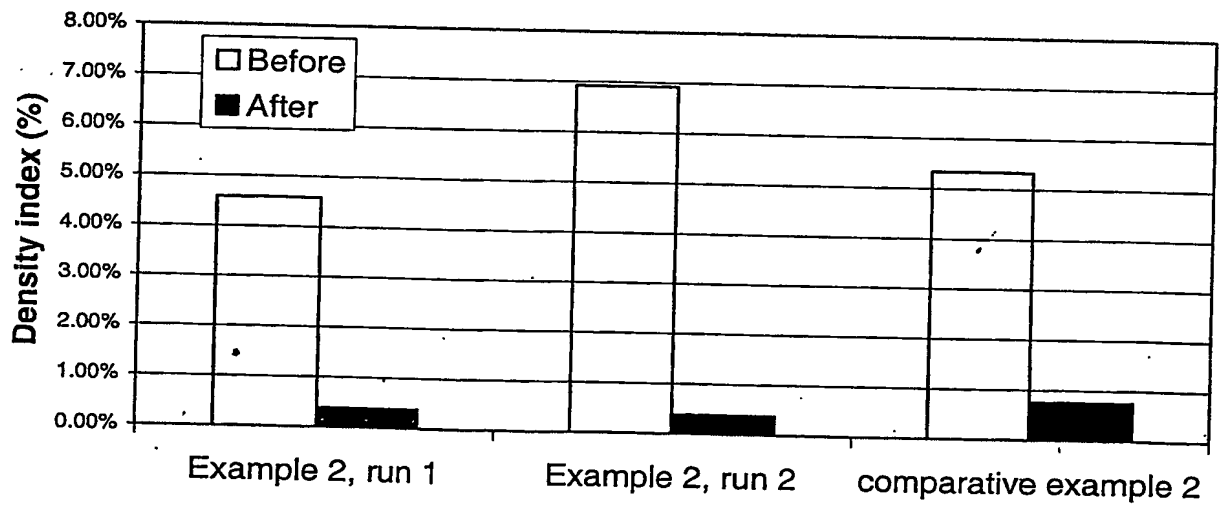
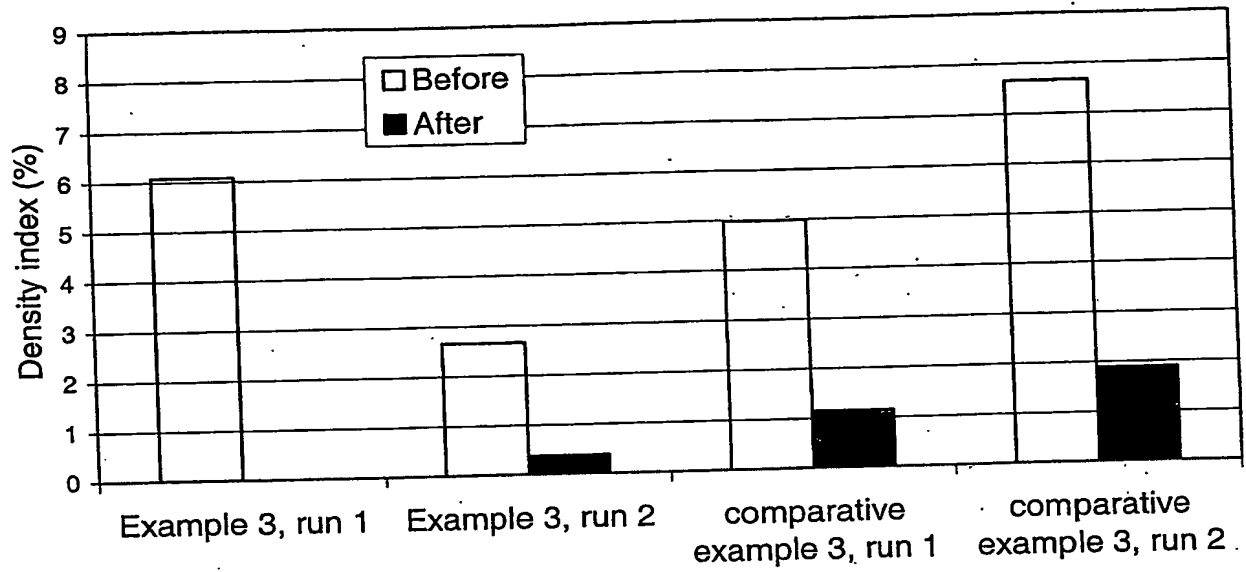


Figure 5



5/5

Figure 6



PCT Application
PCT/GB2003/005492

